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BOND YIELD SPREADS IN THE EUROZONE

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Abstract

Euro Area sovereign bond yield spreads fell significantly after the creation of the monetary union and moved in unison until the recession of 2008, when investors' risk pricing changed considerably. Rising bond yield spreads caught the attention of economists who tried to find the factors influencing their size. Evolution of bond spreads was mostly related to various macroeconomic factors as well as the soundness of the countries' banking sectors and a general level of risk aversion in the financial markets. Analysis presented in this paper compares bond yield spreads of Euro Area member countries and relates them to their debt levels as well as the liquidity of the securities and a general level of risk aversion. Apart from the usual variables, we also analysed differences in purchasing power to assess the impact of the common monetary policy in the pre-crisis period. After adjusting the model to better explain movements of linear regression residuals, we could not prove a systematic assessment of the above-mentioned factors except for time periods of high market volatility. We explain sudden changes in the importance of idiosyncratic factors as consequences of policies of the European Central Bank and other European Union institutions following such time periods, which, as our analysis suggests, distorted pricing of risk in the markets.

Keywords: bond spread, bond yield, Euro Area, monetary union, EMU

JEL classification: E42, G15

1. INTRODUCTION

Increased bond yields of certain Euro Area countries after the start of the mortgage and financial crisis caused serious problems for many governments and even gave rise to questions about several members exiting the common currency block. The financial and economic situation in the region prompted several governments to resign to various bailout schemes organized by the EU and the IMF. Yield spreads among government bonds, which had been minimal since the start of the monetary union, were once again relatively large, reflecting different risk premium. Investors' risk pricing changed after the onset of the mortgage and financial crisis when spreads of individual Euro Area countries widened. Economists focused

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on identifying the factors that caused this rise in yield spreads, testing the importance of factors theoretically relevant in determining bond yield spreads and assessing the exact size of their impact on spreads. In times of global financial uncertainty, investors seek securities with lower credit risk and higher liquidity, driving spreads of lower-quality bonds up. This was also the case in the Euro Area, whose common monetary policy and low inflation risk decreased differentials in sovereign bond yields of its member countries to a minimum, but deterioration in their public finances raised their risk premiums back to previous levels; however, this time monetary policy remained outside of their control.

Euro Area sovereign bond yields used to move in unison but started to be influenced by different factors from 2008 on. Economists tried to find the factors influencing the developments in Euro Area bond markets and the price for risk assigned to them by the markets. Most empirical studies stress the importance of credit risk, illiquidity, and global risk aversion as drivers of sovereign bond spreads but also include variables which capture other relevant factors, such as the situation in the banking sector of individual Euro Area members. Their findings point out to distinct differences between risk pricing before the financial crisis and afterwards. Risk pricing after the start of the financial crisis seems to be more in line with the theory but also appears to price in various risks that are not justified by theoretical assumptions. These studies test the relevance of credit risk, liquidity, and international risk aversion as the main drivers of increasing bond yields. These variables enter as endogenous variables in linear regression while the dependent variable is bond spreads to Germany. The resulting coefficients differ significantly depending on the time period; macroeconomic variables often showing little relevance before 2007/2008.

The aim of this paper is to analyse and show the importance of several factors most commonly listed by literature as determining bond yield spreads throughout a longer time period and compare the results with the results of other authors. The paper is organized into four chapters. The [second chapter](#) reviews related literature. It lists a few other papers with common analyses and briefly comments on their findings. The [third chapter](#) describes our data and methodology which includes variables commonly used in other authors' regressions as well as a few other variables. The [fourth chapter](#) describes our findings and the [last chapter](#) then comments on our findings as well as the findings of other authors. It tries to compare them, find similarities, and explain the differences.

2. LITERATURE REVIEW

In this section we aim to review some literature related to the issue of Euro Area Bond Yield Spreads. We describe methods and results of other authors and compare them. Most of these authors use similar methodology but analyse slightly different time periods and factors influencing bond spreads. We will focus our attention on three papers: [Barrios *et al.* \(2009\)](#); [Barbosa and Costa \(2010\)](#) and [Afonso *et al.* \(2012\)](#). We will describe the results of these authors more in depth but we will also briefly describe some new findings of other authors. We begin this chapter with a description of the methodology used by other authors, which can then be compared to our methodology.

All the above-mentioned authors used linear regression analysis in order to assess the influence of several variables on bond spreads of Euro Area countries. The most important variables in these regressions are credit risk, liquidity, and risk aversion. While the two former variables can be assessed relatively easily, the last one is sometimes hard to estimate. These authors therefore use principal component analysis to find common patterns in

financial markets which could be attributed to different levels of risk aversion in international financial markets. Apart from this, many authors also analyse common patterns in the movement of European bond spreads. This analysis was applied by [Barrios *et al.* \(2009\)](#) and [Afonso *et al.* \(2012\)](#).

[Barrios *et al.* \(2009\)](#), compared the first components of 2 principal component analyses: the first principal component of Euro Area sovereign bond yield spreads and the first principal component of 4 various risk indicators: corporate bond spreads in AAA- and BBB- bonds, euro-yen exchange rate volatility and stock price volatility. The latter was used as a measure of global risk aversion in international markets. The two resulting first principal components proved a close relation between risk aversion and bond spreads from June 2005 to September 2008. However, when comparing the two components, there was a sudden divergence of the two first components at the start of the financial crisis. Until the start of the financial crisis, both of the components moved in unison, reacting similarly to external shocks, but this changed after the start of the financial crisis when there was a relative increase in the price of risk for European sovereign bonds without a corresponding increase in risk aversion.

[Afonso *et al.* \(2012\)](#) also used PCA to identify common patterns in Euro Area bond yield spreads. The first component included similar loadings for all the included countries but the second component showed positive values only for the core countries and negative values for countries hit by the debt crisis. The second component was therefore identified as measuring transmission effects of the debt crisis to the so-called core countries. It explained around 15% of the variance, whereas the rest of the components did not seem to affect the evolution of bond spreads strongly. The second principal component, which was calculated by [Barrios *et al.* \(2009\)](#) for a slightly shorter time period (Jan 2005 – Jul 2009), resulted in negative weight for all the countries except for Ireland, Greece, and Austria whose banking systems were already influenced by the crisis at the time of writing; suggesting a similar finding.

[Barrios *et al.* \(2009\)](#), found general risk perception to be the most important but not the only factor in determining the size of sovereign spreads in the Euro Area. The data seems to suggest that while relevance of domestic fiscal indicators is higher in times of heightened risk aversion, it is especially their interaction with higher risk aversion that raised bond spreads. They studied weekly changes in bond spreads to Germany and, like many other authors they also used linear regression to find the price for risk assigned to various risk factors, both idiosyncratic and other. Independent variables entering the regression analysis were expressed in relation to Germany and included changes in CDS spreads as a measure of credit risk and changes in bid-ask spreads as an estimate of liquidity. The first principal component of risk indicators was also included as an estimate of general risk perception. Finally, they included a crisis variable equal to one from September 2009 onwards and zero otherwise.

Credit risk was significant in case of Austria, Italy, Portugal, Spain, and Greece, whereas liquidity was important in determining yield spreads of France, Greece, and Italy. Risk aversion, on the other hand, was relevant mainly for Belgium, France, Italy, and Portugal. The above-mentioned crisis-effect variable was significant for all countries except Spain and Italy. Calculating coefficients for separate time periods, before and after the start of the financial crisis, showed a limited effect of idiosyncratic factors on bond spreads before the start of the financial crisis and significantly lower explanatory power. However, risk aversion indicator was significant for all countries except for Austria.

Another study of this kind is [Barbosa and Costa \(2010\)](#) which analyzed bond yield spreads between January 2007 and May 2010. The countries included in their analysis were

the initial Euro Area members except for Luxembourg. They used securities with residual maturity of around 5 and 10 years; using CDS premiums and a weighted average of forecasts of macroeconomic variables related to public finances and countries' external position as measures of credit risk. The authors concluded that forecasts of international institutions explain changes in credit risk premiums better than observed data. Barbosa and Costa's measures of liquidity are expressed in relation to Germany and include a wide range of variables; such as transactions costs, trading volumes, and outstanding amounts. International risk appetite was measured using the first principal component of several measures of risk aversion: corporate bond spreads, CDS premiums, market volatility, etc.

Their findings suggest a significant increase in the importance of idiosyncratic factors after the collapse of Lehman Brothers. Their importance was smaller during the time period leading up to the start of the financial crisis when the main determinant of sovereign bond yield spreads was global risk aversion. The importance of credit risk and liquidity increased after September 2008. Liquidity conditions proved to be relevant especially in case of securities with shorter residual maturity; securities with longer residual maturity, on the other hand, displayed higher contribution of credit risk. Macroeconomic variables were relevant in determining bond yield spreads both in case of variables describing recent trends as well as their baseline position. Credit risk was relevant especially in case of Greece, but also Italy and Portugal. Liquidity did not seem to affect big economies, such as Italy and France.

Afonso *et al.* (2012) also used linear regression to test the relevance of macroeconomic variables and international risk aversion but also included other variables, which were not included in the former analyses: lagged spread, real exchange rate, growth of industrial production, and a crisis' transmission indicator, which is the second principal component of sovereign bond spreads to Germany. The purpose of their analysis was to find common coefficients for all the included countries, which included the so-called core countries as well as South European countries. Their regression analysis proved only lagged spread, risk perception, liquidity indicator, and growth of industrial production significant at 1% level. The rest of the variables, including crisis' transmission indicator and macroeconomic indicators capturing the level of indebtedness, were insignificant. Inclusion of a multiplicative term which multiplied past spread level and bid-ask spread (their liquidity indicator) proved significance of the interaction of spreads and liquidity at 1% level. Including this variable made the liquidity indicator insignificant and close to zero while significance of the government budget balance changed from 1% to 5%.

The former regressions were repeated using the same variables and their multiplications with dummy variables equal to one from August 2007 and March 2009 on and zero otherwise in order to find any changes in market's perception of risk over time. Including these dummy variables slightly improved the explanatory power of the regression analysis. The results showed that risk perception was only relevant to determining spreads from August 2007 onwards, but not from March 2009 onwards. The variable itself without a multiplicative term was insignificant which contradicts the findings of the former authors Barrios *et al.* (2009) and Barbosa and Costa (2010) who assumed risk perception to be the main driver of bond spreads before the financial crisis but who also used a slightly different approach. All of the authors used market volatility as measures of risk perception but the former authors also included data from bond spreads in their risk aversion indicators. This difference in data and methodology might have been the reason of different findings.

Coefficient of the crisis' transmission to the core countries, which was insignificant in the first analysis, was significant when multiplied by the March 2009 dummy variable.

While multiplication by the August 2007 dummy variable resulted in a coefficient with higher significance, the coefficient was negative. There seems to be a compensation for this after March 2009 when the coefficient is positive and higher, which makes also the sum of both of the coefficients positive. Significance of macroeconomic fundamentals rose; budget balance was significant and debt-to-GDP was significant after March 2009. Liquidity, which was insignificant in the former analyses, was significant when multiplied by the March 2009 dummy variable. The share of long-term government debt in the overall stock of debt was also insignificant when added to the former analysis but exhibited quite a high significance after being multiplied by both of the dummy variables. The coefficient for March 2009 is negative, and the sum of the 2 coefficients is also negative, which the authors interpreted as the ability to successfully place long-term debt priced with lower spreads by the markets. Spread multiplied by the bid-ask spread was only significant after inclusion of the March 2009 dummy variable; however, negative.

Overall, the above-mentioned authors found that the markets did not price in macro- and fiscal fundamentals in sovereign spreads until the start of the mortgage crisis; the role of liquidity also seems to be limited during this time period. Many cited authors assume international risk aversion to be the main driver of bond spreads in this time period, [Barrios *et al.* \(2009\)](#) and [Barbosa and Costa \(2010\)](#) among them. Credit risk seems to be relevant; with certain sovereigns exhibiting permanently higher spreads irrespective of their fiscal position. However, credit risk premium did not seem to be affected by market volatility and market uncertainty that much. Slightly higher risk premiums seemed to reflect differentials in bond yields from before the start of the monetary union. These differentials (before 1999) arose mostly because of higher inflation rates of certain countries. These countries managed to fulfil the Maastricht criteria and decrease the level of inflation but kept higher levels of inflation because of increasing productivity rates even after the start of the monetary union. High inflation rates in an environment with equal nominal interest rates made the real interest rates of these countries relatively low, which had adverse effects on their banking systems. [Mody and Sandri \(2011\)](#) in their paper stress the importance of the soundness of the banking system for economic growth. Their analysis proves its importance in determining the level of spread and shows that it became a significant risk factor after the start of the mortgage crisis in 2007. The authors compared the ratio of a financial sector equity index and an overall stock market index of Euro Area members to 10-year sovereign spreads. Then they used this data in regression analyses to prove and calculate the exact size of its influence on bond spreads. The influence of the soundness of the banking sector on bond spreads was obvious. Since we assumed that the banking sector was affected by equality of interest rates across the whole region, we decided to include variables that could capture some implications of this equality: country-specific inflation rates, real exchange rates, and loss of purchasing power. These variables were not included in the former analyses, which mostly focused on different kinds of variables instead.

The next chapter deals with the data and methodology used in our own analysis to determine the influence of several factors on the size of bond yield spreads to Germany. At first we list the variables included in our model and justify their inclusion. In the second part of the chapter we describe our data and the details of our model as well as an adjusted model which does not give autocorrelated residuals. Adjusting the model led to low explanatory power, which is why we decided to take on a different approach and analyse various time periods to find any changes in the patterns of risk pricing. Our approach showed that some variables were only significant during certain time periods, which supports the idea that risk

pricing of sovereign bonds changed at a certain point in time under the impact of the financial and economic crisis.

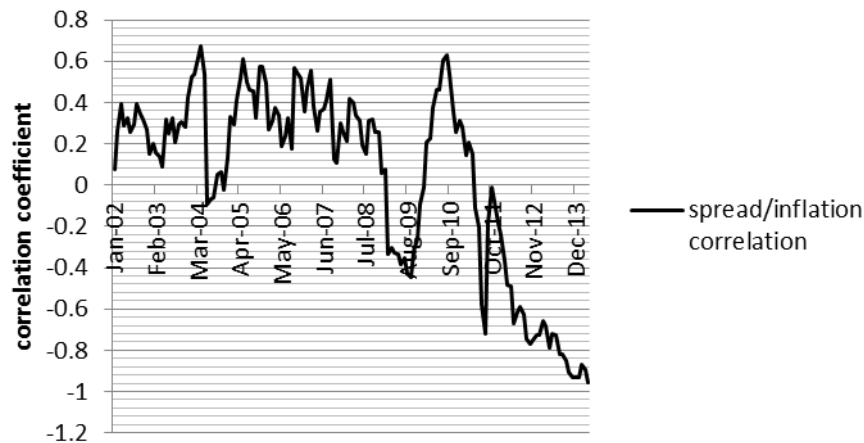
3. DATA AND METHODOLOGY

We used a very similar methodology to the methodologies of the above-mentioned papers. We analysed the influence of credit risk, liquidity and risk aversion during the whole time period of 2002 to 2013 using regression analysis and repeated this analysis for different time periods. Countries included in the analysis were Euro Area members with the exception of smaller countries and new member states: Belgium, Ireland, Greece, Spain, France, Italy, the Netherlands, Austria, Portugal, and Finland. Sovereign yield on German bonds was used as the risk-free rate for the Euro Area. Each of the countries was analysed separately, based on monthly data. Spread between the respective country's yield on its 10-year sovereign bonds over German bond yields ([European Central Bank, 2014](#)) was used as the dependent variable. The whole time period of the analysis is January 2002 to December 2013, which accounts for 144 observations. We decided to analyse time periods with different risk pricing separately to be able to observe any changes in investors' risk perception. The overall time period was therefore divided into 2 shorter time periods: time period before the financial crisis that started in September 2008 (80 observations) and time period after the start of the financial crisis (64 observations).

The influence of credit risk, liquidity and risk aversion was analysed for two distinct time periods: January 2002 to August 2008 and September 2008 to December 2013. The analysis of the time period before the financial crisis was then compared with a similar analysis including inflation and real interest rates, which is in line with the assumption that high inflation levels damaged the European banking sector, which later proved to play a significant role in determining the size of the spread after the start of the financial crisis – [Mody and Sandri \(2011\)](#). High inflation rates made real interest rates too low for certain countries, which increased their growth and made borrowing cheaper for both the government and the banking sector. As a result, countries that had had high rates of inflation and paid relatively high interest rates before joining the monetary union could finance their debt more easily after joining the monetary union due to lower interest rates. They managed to meet the Maastricht criteria but their economies required slightly higher interest rates than interest rates imposed by the European Central Bank after the joining the monetary union. Inflation also influences balance of trade through price adjustment, which leads to different levels of both public and private debt. We assumed that real interest rates might have already been priced in bond spreads and repeated the analysis using both inflation and real interest rates. Then we substituted these variables with the loss in purchasing power relative to Germany since the start of the currency union and irrevocable fixing of interest rates. We included inflation rates in our 2002 to 2008 regression but did not do so for the rest of the regressions because spreads seem to react to slow economic growth, high debt, and budget cuts which are associated with low inflation and deflation. The resulting regression would therefore reflect influence of economic growth on spreads rather than support our hypothesis.

European countries experienced quite different inflation rates during the 2002 to 2008 time period; the difference sometimes being even 2% between 2 Euro Area regions. Their productivity and purchasing power changed over time and differed more but their nominal interest rates and nominal exchange rates were equal for all the regions. This had implications for their growth rates as well as their ability to service debt. While this might have improved

growth rates in many cases, it made their growth unequal over time. We assumed that low real interest rates would increase indebtedness of all of the sectors (as opposed to just the public sector expressed in the debt/GDP variable) and thus might capture tendency to create more debt. Moreover, high inflation induces to dissave and when it suddenly decreases, the country's ability to service its debt is threatened. Country-specific inflation rates and individual country spreads are positively correlated at certain time periods (usually when growth rates are also relatively high) and negatively correlated at other time periods (mostly in times of slower growth). They are hardly ever close to zero – see [Figure no. 1](#).



Source: *ECB Statistical Data Warehouse (2014a, 2014b, 2014c, 2014d)*, *Stoxx (2014)*, own calculations

Figure no. 1 – Spread/Inflation Correlation

Similarly to the above-mentioned analyses, we supposed that credit risk, liquidity, and risk aversion would be the main drivers of bond spreads, and included these variables in our regressions¹. Credit risk was measured as government debt to GDP ([European Central Bank, 2014](#)), which captures a large part of the government's ability to meet its liabilities. Unfortunately, this data is not available on a monthly basis. Therefore we used quarterly data published by the ECB.

Second independent variable in our regression was liquidity. Literature lists multiple measures of liquidity conditions in the markets. These measures usually depend on the value of transactions, outstanding amounts, and transaction costs. We used the value of outstanding amounts published by the ECB ([European Central Bank, 2014](#)) on a regular basis. These included the value of long-term government debt, which was compared to the value of outstanding amounts of long-term government debt of Germany. We created a ratio of values of Germany to the values of each country in order to capture the different liquidity conditions in comparison with the benchmark bonds. This approach is different from the one used in credit risk. Credit risk was not compared to Germany, although heightened credit risk in comparison with the benchmark should raise spread. Even though many studies express credit risk in relation to Germany, we did not do so, as there does not seem to be a strong relation between spread and relative credit risk. Markets seem to price credit risk based on actual data instead.

Risk aversion was measured based on volatility in the stock market as well as in the money markets. Stock market data was retrieved from the STOXX Global 3000 index (Stoxx, 2014), which included stock prices from all over the world, and thus better captures risk perception reflected in price movements in international stock markets. Data from the money markets was retrieved from the ECB (European Central Bank, 2014), which publishes daily data on the EUR/USD exchange rate. We calculated monthly variation coefficients based on daily data of both of these data sets, out of which we created a moving average at the length of 7 months. This data was then used in principal component analysis – Bohdalová and Greguš (2012) in calculation of the first principal component, which should reflect common patterns in variance in both of the markets. Heightened variance in stock and foreign exchange markets is usually due to higher international risk perception. We assumed therefore that the first principal component out of this data would capture global risk aversion. The first principal component explains 95.6% of the variance of the data.

The results of the 2002-2008 analysis were then compared to the results of the same analysis that included also other variables: inflation², real interest rate³, and an overall change in purchasing power⁴ since the start of the monetary union. Inflation rates were taken from the European Central Bank (European Central Bank, 2014) and used in the next regression model, which included real interest rates, calculated based on ECB main refinancing rates (ECB Statistical Data Warehouse, 2014b) and interest rates. Since these regressions resulted in autocorrelated residuals, we adjusted the model further using differences and natural logarithms of our variables⁵. Our independent variables were almost all insignificant for the chosen time periods. Therefore we decided to take on a different approach and use this model with data of various time lengths. All of the used time periods started in January 2002 and went further into the future until the last analysis which ended in December 2013. We decided to analyse time periods with different risk pricing separately to be able to observe any changes in investors' risk perception. The purpose of these analyses was to find when changes in risk pricing occurred as the markets evolved under the changing economic environment, debt crisis, persisting banking sector issues, extremely low interest rates, and an altering balance of trade. In line with the hypothesis that the markets started to price in idiosyncratic factors only after the start of the financial crisis of 2008 or later on, we repeated the analysis with an increasing number of observations to find when this change in risk pricing occurred. Our data starts in January 2002 and ends in December 2013. The shortest time period of our analysis contains 50 observations, which corresponds with the time period between January 2002 and February 2006. The following analyses include more observations. The longest time period accounts for 144 observations.

The next chapter describes our results and comments on our findings. It also tries to compare our results with the results of other authors. Even though our methodology, data, time period of analysis, etc. were slightly different, we did find both similarities as well as differences in the results. Our analysis confirmed that country-specific factors were important mostly after the start of the financial crisis, and they did not influence bond spreads of European government debt to a great extent before the crisis. We found that risk aversion affected bond spreads throughout the whole time period of our analysis, and it also seems that changes in purchasing power and their differences across the whole region might have played a role in determining the cost of government debt before the crisis. The results of the adjusted models suggest that markets perceived different factors as determining to sovereign bond yields, and that the importance of these factors evolved over time differently for each country.

4. RESULTS

The results of the regression analysis (1) are shown in *Table no. 1*. Significance of the analysis is quite high, with the exception of Austria and Finland, where the explanatory power is limited. These countries did not face high public debt nor high sovereign bond yields. On average, the linear regression did not explain the size of the spread of countries with low borrowing costs to such a great extent as it was in the case of countries with high borrowing costs, whose bond yields were affected by the level of their debt and the overall situation in the region's economy.

Table no. 1 – Bond Yield Spreads from 2002 until 2013

Spread 2002-2013	Belgium	Ireland	Greece	Spain	France	Italy	Netherlands	Austria	Portugal	Finland
multiple R	0.86	0.80	0.77	0.86	0.87	0.92	0.86	0.57	0.85	0.66
constant	-12.83	1.64	-21.95	-7.71	-6.41	-23.54	-2.05	-6.77	-11.29	-1.52
<i>p value</i>	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t-stat	-17.81	1.26	-9.85	-3.09	-7.44	-21.61	-13.52	-6.76	-4.79	-8.98
lower interval (95%)	-14.26	-0.94	-26.35	-12.64	-8.11	-25.69	-2.35	-8.75	-15.96	-1.85
upper interval (95%)	-11.41	4.23	-17.54	-2.78	-4.71	-21.38	-1.75	-4.79	-6.63	-1.18
credit risk	6.43	3.30	21.58	10.35	3.76	10.32	1.97	5.04	12.77	1.62
<i>p value</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t-stat	14.09	4.09	11.63	6.76	16.53	18.04	18.69	7.83	16.03	7.65
lower interval (95%)	5.53	1.70	17.91	7.32	3.31	9.19	1.76	3.77	11.20	1.20
upper interval (95%)	7.33	4.89	25.24	13.38	4.22	11.45	2.18	6.31	14.35	2.03
liquidity	1.53	-0.08	-0.06	1.08	3.22	13.24	0.20	0.43	0.19	0.04
<i>p value</i>	0.00	0.02	0.57	0.05	0.00	0.00	0.00	0.00	0.17	0.00
t-stat	17.77	-2.44	-0.57	2.00	5.36	11.99	8.78	5.06	1.38	9.43
lower interval (95%)	1.36	-0.15	-0.28	0.01	2.03	11.06	0.16	0.26	-0.08	0.03
upper interval (95%)	1.70	-0.02	0.15	2.14	4.41	15.42	0.25	0.60	0.46	0.05
risk aversion	5.67	9.87	9.48	-4.78	2.17	15.23	1.72	3.28	18.93	2.82
<i>p value</i>	0.00	0.06	0.54	0.07	0.00	0.00	0.00	0.00	0.00	0.00
t-stat	4.64	1.92	0.62	-1.80	3.33	6.60	4.88	2.96	2.97	5.27
lower interval (95%)	3.25	-0.32	-20.91	-10.01	0.88	10.67	1.02	1.09	6.34	1.76
upper interval (95%)	8.09	20.06	39.86	0.46	3.46	19.79	2.41	5.46	31.52	3.87

Note: Coefficients are significantly different from zero at 95% level if their *p*-values are equal to 0.05 or lower (Wonnacot and Wonnacot, 1990, p. 125)

Source: ECB Statistical Data Warehouse (2014a, 2014b, 2014c, 2014d), Stoxx (2014), own calculations

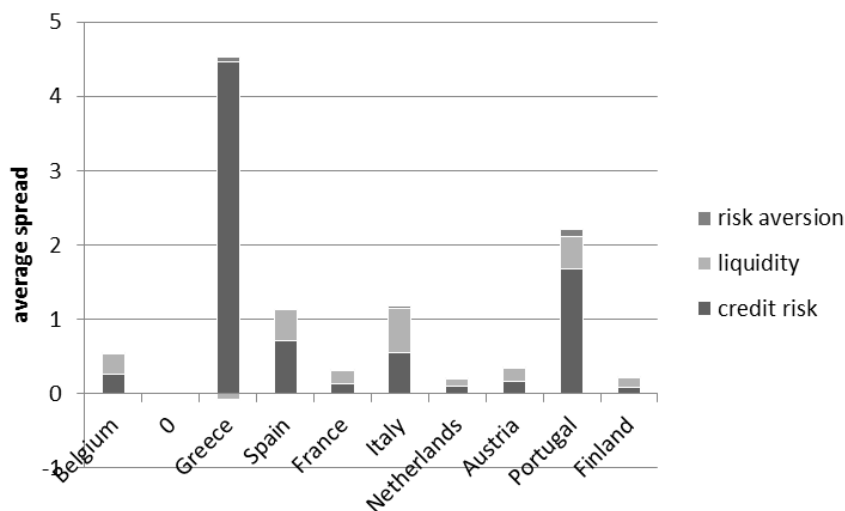
Except for a few coefficients, all the variables have the expected sign. Negative sign was found in the coefficient of liquidity for Ireland and Greece; however, liquidity was insignificant for Greece. It seems that credit risk was so important in determining the size of the spread for Greece that it made the rest of the variables insignificant and almost unimportant. The negative sign might have resulted from the fact that we measured liquidity using the value of outstanding amounts, which rises with higher debt. This might have slightly affected also other calculated coefficients. The coefficient of risk aversion of Spain is also negative, but its significance is quite weak.

Risk aversion variable did not differ across countries and the size of the coefficients can be easily compared. Its significance is satisfactory except for Ireland, Greece, and Spain. Its importance can be ruled out for Greece, whereas its significance in case of Ireland and Spain can still be taken into account. The size of the significant coefficients ranges from the minimum value of 1.72 in the Netherlands to 18.93 in Portugal (see *Table no. 1*).

International risk aversion seems to have a small impact on the size of the spread of France, the Netherlands, Austria, and Finland, while it affects highly-indebted countries, such as Italy and Portugal but also Ireland. The results seem to suggest that risk aversion affected mostly countries with higher debt.

Liquidity was significant for all the countries except for Portugal and Greece. The significance of Ireland's coefficient is lower but still satisfactory; however the coefficient is negative, which might suggest that liquidity did not affect its spread. Liquidity coefficient is exceptionally large for Italy, and is relatively high for France, Belgium, and Spain. Overall, liquidity seems to have affected mostly larger economies.

All of the credit risk coefficients were significant, and their size seems to depend not only on the indebtedness of the countries but also on the situation in the banking sector. The most affected country seems to be Greece, followed by Portugal, Spain, and Italy. The coefficients for Belgium and Austria are also relatively high. The size of the coefficients seems to point to an interaction of credit risk and risk aversion, except for Greece and Spain where risk aversion is insignificant. Countries with generally less sound banking sectors, such as Ireland, Spain, and Austria featured higher coefficients than would have normally been expected judging by their level of public debt.



Source: ECB Statistical Data Warehouse (2014a, 2014b, 2014c, 2014d), Stoxx (2014), own calculations

Figure no. 2 – Contribution to Spread (2002-2013)

Credit risk and liquidity data is different for each of the countries and can be compared more easily when shown graphically: see Figure no. 2 and Figure no. 3. Ireland was excluded from Figure no. 2 because it would dwarf the data of other countries. The chart shows the contribution of the average size of each of the data sets based on the calculated coefficients. The resulting size of the columns is the average size of the spread during the time period of the analysis. The chart suggests that credit risk is the most important factor, followed by liquidity conditions, while the importance of risk aversion seems to be limited. Credit risk clearly contributes to the spread of highly-indebted countries more than countries with low debt. Moreover, the size of the calculated coefficients also shows that the yields of

these countries are more sensitive to changes in the level of their public debt. In general, they also face higher yields in times of worse liquidity conditions.

The results of the January 2002 to August 2008 analysis are a lot lower in significance (Table no. 2). Credit risk coefficients are either insignificant or negative. The only exception is Ireland whose credit risk coefficient is positive and significant at the same time. The results for liquidity are similar. The only positive and significant coefficient was Italy's liquidity coefficient. Risk aversion, on the other hand, was significant for most of the countries. Insignificant were only the Netherlands, Austria, and Portugal. These countries also exhibited relatively low coefficients. These coefficients are very similar in size, especially when compared to the previous analysis for 2002 to 2013 (Table no. 1). A slightly higher coefficient was assigned to Greece, while the rest of the countries' coefficients were between 1 and 2. Low significance of the credit risk and liquidity variables and importance of global risk perception are in line with the previous analysis of Barrios *et al.* (2009) and Barbosa and Costa (2010) but slightly contradicts the findings of Afonso *et al.* (2012). The former authors assumed risk aversion to be the most important determinant of bond yield spreads before the financial crisis, and our results support these findings. Low significance of idiosyncratic factors in this analysis might suggest that there were other factors affecting sovereign spreads, since they continued to differ slightly even after the creation of the monetary union.

Table no. 2 – Bond Yield Spreads from 2002 until 2008

Spread 2002-2008	Belgium	Ireland	Greece	Spain	France	Italy	Netherlands	Austria	Portugal	Finland
multiple R	0.56	0.65	0.76	0.60	0.45	0.48	0.52	0.62	0.69	0.67
constant	2.00	-0.20	0.75	0.13	0.17	-0.43	0.71	2.02	1.52	0.54
<i>p value</i>	0.01	0.45	0.12	0.88	0.74	0.60	0.09	0.00	0.00	0.02
t-stat	2.80	-0.76	1.59	0.15	0.34	-0.52	1.72	4.31	3.17	2.46
lower interval (95%)	0.57	-0.73	-0.19	-1.59	-0.83	-2.06	-0.11	1.09	0.56	0.10
upper interval (95%)	3.42	0.33	1.70	1.86	1.17	1.21	1.54	2.96	2.47	0.98
credit risk	-1.20	1.20	0.27	-0.45	0.81	-0.45	-1.11	-1.48	-0.13	-1.06
<i>p value</i>	0.00	0.00	0.42	0.52	0.02	0.45	0.03	0.00	0.71	0.00
t-stat	-2.99	2.96	0.81	-0.65	2.31	-0.76	-2.27	-4.80	-0.37	-2.98
lower interval (95%)	-2.01	0.39	-0.39	-1.81	0.11	-1.62	-2.08	-2.09	-0.84	-1.76
upper interval (95%)	-0.40	2.01	0.93	0.92	1.51	0.72	-0.14	-0.87	0.58	-0.35
liquidity	-0.18	0.00	-0.14	0.03	-0.53	1.20	-0.02	-0.12	-0.09	0.00
<i>p value</i>	0.03	0.51	0.00	0.87	0.07	0.00	0.54	0.00	0.00	0.27
t-stat	-2.28	-0.66	-5.19	0.17	-1.87	3.77	-0.61	-3.28	-4.88	-1.12
lower interval (95%)	-0.33	-0.02	-0.19	-0.31	-1.09	0.56	-0.09	-0.19	-0.12	-0.01
upper interval (95%)	-0.02	0.01	-0.08	0.36	0.03	1.83	0.05	-0.05	-0.05	0.00
risk aversion	1.37	1.98	2.28	1.79	1.04	1.77	0.41	0.45	0.55	1.50
<i>p value</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.17	0.27	0.00
t-stat	4.16	3.54	7.19	6.54	3.79	3.64	1.92	1.39	1.11	5.85
lower interval (95%)	0.71	0.86	1.65	1.24	0.49	0.80	-0.02	-0.19	-0.43	0.99
upper interval (95%)	2.02	3.09	2.92	2.33	1.59	2.74	0.84	1.09	1.53	2.01

Note: Coefficients are significantly different from zero at 95% level if their *p*-values are equal to 0.05 or lower (Wonnacot and Wonnacot, 1990, p. 125)

Source: ECB Statistical Data Warehouse (2014a, 2014b, 2014c, 2014d), Stoxx (2014), own calculations

Regression analysis of the 2008 to 2013 time period (Table no. 3) had a relatively high significance for several countries, where its explanatory power was comparable to or even higher than in the previous analysis including data from 2002 to 2013. However, the significance of the analysis was a lot lower for several other countries, namely Greece, Ireland, and the Netherlands.

Table no. 3 – Determinants of Bond Spreads from 2008 until 2013

Spread 2008-2013	Belgium	Ireland	Greece	Spain	France	Italy	Netherlands	Austria	Portugal	Finland
multiple R	0.80	0.51	0.49	0.79	0.71	0.92	0.56	0.64	0.74	0.56
constant	-17.38	-4.97	-27.62	-12.39	-9.26	-26.32	-1.03	-5.47	-17.99	0.23
<i>p value</i>	0.00	0.10	0.04	0.00	0.00	0.00	0.22	0.00	0.00	0.81
t-stat	-8.78	-1.66	-2.13	-3.10	-5.93	-11.15	-1.23	-4.59	-3.61	0.24
lower interval (95%)	-21.34	-10.96	-53.52	-20.38	-12.38	-31.05	-2.69	-7.86	-27.96	-1.63
upper interval (95%)	-13.42	1.02	-1.73	-4.39	-6.13	-21.60	0.64	-3.08	-8.02	2.08
credit risk	5.79	6.67	23.73	12.33	5.26	5.71	1.84	5.09	18.97	-0.08
<i>p value</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92
t-stat	4.42	3.94	3.22	5.42	7.55	3.47	3.19	4.26	6.89	-0.10
lower interval (95%)	3.17	3.28	9.01	7.78	3.86	2.42	0.69	2.70	13.46	-1.59
upper interval (95%)	8.41	10.06	38.45	16.88	6.65	8.99	3.00	7.49	24.47	1.43
liquidity	2.57	-0.02	-0.01	2.23	4.38	21.96	-0.01	0.24	-0.05	0.00
<i>p value</i>	0.00	0.86	0.98	0.02	0.00	0.00	0.94	0.02	0.91	0.97
t-stat	9.51	-0.17	-0.03	2.31	4.27	13.78	-0.07	2.46	-0.12	0.04
lower interval (95%)	2.03	-0.19	-0.42	0.30	2.33	18.77	-0.20	0.05	-0.84	-0.05
upper interval (95%)	3.12	0.16	0.41	4.16	6.43	25.15	0.18	0.44	0.74	0.05
risk aversion	16.11	110.21	101.48	19.25	11.70	15.32	10.09	19.80	163.79	7.15
<i>p value</i>	0.00	0.00	0.44	0.29	0.01	0.14	0.00	0.00	0.00	0.00
t-stat	3.20	3.06	0.77	1.07	2.76	1.51	5.05	5.45	3.64	3.00
lower interval (95%)	6.04	38.19	-160.46	-16.68	3.20	-4.97	6.10	12.53	73.71	2.38
upper interval (95%)	26.18	182.23	363.42	55.18	20.19	35.60	14.09	27.07	253.86	11.91

Note: Coefficients are significantly different from zero at 95% level if their *p*-values are equal to 0.05 or lower (Wonnacot and Wonnacot, 1990, p. 125)

Source: ECB Statistical Data Warehouse (2014a, 2014b, 2014c, 2014d), Stoxx (2014), own calculations

Credit risk's significance was very high with the exception of Finland. Liquidity was significant for Belgium, Spain, France, Italy, and Austria, and did not seem to affect the rest of the countries at all. Again, liquidity coefficients are higher for bigger countries, namely Italy, but also France. Similarly to the 2002 to 2013 analysis, the highest credit risk coefficients are found in Greece, Portugal, and Spain. On the other hand, Belgium, Ireland, France, Italy, and Austria show slightly lower coefficients, whereas the dependency of sovereign spreads on debt to GDP did not seem that strong for the Netherlands. An exceptionally high risk aversion coefficient was found in Portugal and Ireland. The rest of the countries share quite similar coefficients. Risk aversion was insignificant for Greece, Spain, and Italy, so we could not confirm interaction of risk aversion and credit risk any more. The results show differences in comparison to the previous analysis. Liquidity in general is not as important to determining the size of the spread as for the whole 2002-2013 period. Debt crisis made spreads more sensitive to credit risk than to liquidity risk. The size of the risk aversion coefficients also suggests that spreads were affected by international risk aversion to a much greater extent than during the 2002-2008 period.

Table no. 4 – Determinants of Bond Spreads from 2002 until 2008 including inflation

Spread 2002-2008	Belgium	Ireland	Greece	Spain	France	Italy	Netherlands	Austria	Portugal	Finland
multiple R	0.79	0.70	0.86	0.67	0.76	0.80	0.64	0.79	0.69	0.74
constant	0.15	0.31	-0.06	0.81	0.39	-2.41	0.22	1.73	1.64	-0.37
<i>p value</i>	0.80	0.31	0.88	0.34	0.29	0.00	0.58	0.00	0.00	0.23
t-stat	0.26	1.02	-0.15	0.97	1.06	-3.96	0.56	4.60	3.19	-1.21
lower interval (95%)	-1.02	-0.30	-0.86	-0.85	-0.35	-3.62	-0.56	0.98	0.61	-0.99
upper interval (95%)	1.32	0.93	0.74	2.46	1.13	-1.20	1.01	2.48	2.66	0.24
credit risk	-0.05	0.32	0.50	-0.93	0.34	0.85	-0.66	-0.95	-0.19	0.57

Spread 2002-2008	Belgium	Ireland	Greece	Spain	France	Italy	Netherlands	Austria	Portugal	Finland
<i>p</i> value	0.89	0.51	0.06	0.16	0.20	0.05	0.15	0.00	0.60	0.28
t-stat	-0.14	0.66	1.87	-1.41	1.29	1.96	-1.45	-3.71	-0.52	1.09
lower interval (95%)	-0.72	-0.65	-0.03	-2.24	-0.19	-0.01	-1.56	-1.46	-0.93	-0.48
upper interval (95%)	0.62	1.30	1.03	0.38	0.87	1.71	0.25	-0.44	0.54	1.61
liquidity	-0.04	-0.02	-0.09	-0.14	-0.54	1.48	0.02	-0.14	-0.09	0.01
<i>p</i> value	0.56	0.02	0.00	0.38	0.01	0.00	0.52	0.00	0.00	0.22
t-stat	-0.59	-2.35	-3.88	-0.88	-2.59	6.68	0.65	-4.91	-4.85	1.24
lower interval (95%)	-0.16	-0.03	-0.13	-0.47	-0.95	1.04	-0.04	-0.20	-0.13	0.00
upper interval (95%)	0.09	0.00	-0.04	0.18	-0.12	1.93	0.08	-0.08	-0.05	0.02
risk aversion	1.48	1.47	1.26	1.35	0.69	1.34	-0.29	0.33	0.64	1.16
<i>p</i> value	0.00	0.01	0.00	0.00	0.00	0.00	0.26	0.21	0.22	0.00
t-stat	5.97	2.61	4.20	4.73	3.34	3.94	-1.14	1.27	1.25	4.64
lower interval (95%)	0.98	0.35	0.66	0.78	0.28	0.66	-0.81	-0.18	-0.38	0.66
upper interval (95%)	1.97	2.59	1.85	1.92	1.10	2.02	0.22	0.83	1.67	1.66
inflation	0.06	0.07	0.09	0.04	0.05	0.14	0.04	0.07	-0.01	0.05
<i>p</i> value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00
t-stat	7.73	2.92	6.54	3.46	8.03	9.14	4.21	6.75	-0.66	3.95
lower interval (95%)	0.04	0.02	0.06	0.02	0.04	0.11	0.02	0.05	-0.05	0.02
upper interval (95%)	0.07	0.11	0.12	0.06	0.06	0.17	0.06	0.08	0.02	0.07

Note: Coefficients are significantly different from zero at 95% level if their *p*-values are equal to 0.05 or lower (Wonnacot and Wonnacot, 1990, p. 125)

Source: ECB Statistical Data Warehouse (2014a, 2014b, 2014c, 2014d), Stoxx (2014), own calculations

Table no. 5 – Determinants of Bond Spreads from 2002 until 2008 including real interest rate

Spread 2002-2008	Belgium	Ireland	Greece	Spain	France	Italy	Netherlands	Austria	Portugal	Finland
multiple R	0.67	0.76	0.76	0.61	0.45	0.49	0.57	0.65	0.74	0.70
constant	0.89	-0.96	0.67	-0.12	0.18	-0.07	0.35	2.25	1.71	0.05
<i>p</i> value	0.20	0.00	0.18	0.89	0.72	0.94	0.42	0.00	0.00	0.87
t-stat	1.30	-3.51	1.36	-0.13	0.36	-0.07	0.81	4.76	3.75	0.16
lower interval (95%)	-0.48	-1.50	-0.31	-1.90	-0.82	-1.95	-0.51	1.31	0.80	-0.53
upper interval (95%)	2.26	-0.41	1.65	1.66	1.19	1.81	1.21	3.19	2.62	0.63
credit risk	-0.64	2.46	0.33	-0.19	0.82	-0.56	-0.97	-1.67	-0.39	-0.46
<i>p</i> value	0.10	0.00	0.34	0.79	0.02	0.36	0.04	0.00	0.26	0.27
t-stat	-1.67	5.75	0.96	-0.26	2.33	-0.93	-2.05	-5.29	-1.13	-1.11
lower interval (95%)	-1.40	1.61	-0.36	-1.63	0.12	-1.78	-1.92	-2.29	-1.08	-1.29
upper interval (95%)	0.12	3.32	1.02	1.25	1.53	0.65	-0.03	-1.04	0.30	0.37
liquidity	-0.07	0.01	-0.14	0.08	-0.56	1.01	0.02	-0.14	-0.08	0.00
<i>p</i> value	0.31	0.06	0.00	0.65	0.06	0.01	0.51	0.00	0.00	0.71
t-stat	-1.03	1.90	-5.19	0.45	-1.95	2.51	0.67	-3.82	-4.82	0.38
lower interval (95%)	-0.22	0.00	-0.19	-0.27	-1.13	0.21	-0.05	-0.21	-0.12	-0.01
upper interval (95%)	0.07	0.02	-0.08	0.42	0.01	1.81	0.10	-0.07	-0.05	0.01
risk aversion	1.92	1.66	2.34	1.66	1.11	1.47	0.21	0.54	0.45	1.58
<i>p</i> value	0.00	0.00	0.00	0.00	0.00	0.02	0.35	0.09	0.34	0.00
t-stat	6.00	3.39	7.04	5.67	3.77	2.34	0.95	1.71	0.96	6.31
lower interval (95%)	1.28	0.68	1.68	1.08	0.52	0.22	-0.24	-0.09	-0.48	1.08
upper interval (95%)	2.55	2.63	3.01	2.25	1.69	2.72	0.66	1.18	1.37	2.08
real interest rate	0.003	-0.003	0.000	-0.001	0.001	-0.002	0.002	0.003	-0.003	0.005
<i>p</i> value	0.00	0.00	0.53	0.26	0.52	0.44	0.02	0.04	0.00	0.01
t-stat	4.43	-5.14	0.63	-1.14	0.64	-0.78	2.39	2.07	-3.24	2.52
lower interval (95%)	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
upper interval (95%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01

Note: Coefficients are significantly different from zero at 95% level if their *p*-values are equal to 0.05 or lower (Wonnacot and Wonnacot, 1990, p. 125)

Source: ECB Statistical Data Warehouse (2014a, 2014b, 2014c, 2014d), Stoxx (2014), own calculations

Since none of the variables from the 2002-2008 regression analysis could explain the size of the sovereign spreads sufficiently, we decided to include other variables. The next analysis (2) includes inflation, which features the highest significance of all the variables and increased the significance of the regression analysis. The only insignificant inflation coefficient of this regression analysis was the one calculated for Portugal. Including inflation in the analysis made the significance of the rest of the idiosyncratic variables a lot lower, while the risk aversion coefficients retained their significance. All of the risk aversion coefficients were significant, except for the Netherlands, Austria, and Portugal. Despite the results it was most probably not inflation risk that investors were pricing in. Especially in monetary unions, where exchange rates are fixed and nominal exchange rates are equal, countries with higher economic growth usually face higher inflation rates. Eurozone members with the highest inflation rates prior to the financial crisis were Greece, Spain, Ireland, but also Portugal, and Italy. These countries exhibited high inflation rates even before joining the monetary union, and their economic growth was faster than the economic growth of the rest of the countries after they joined the monetary union until the financial crisis of 2008. The interest rates imposed by the European Central Bank were too low for them, which resulted in higher inflation rates. However, their economic growth did not translate into a better ability to service debt as perceived by the investors in the financial markets. This level of interest rates was damaging to their economies and made their growth more uneven, which showed after the start of the financial crisis when the economic growth of these countries was lower than that of most of the other members of the currency union. It is possible that the effect of the “too-low” interest rates had already been priced in even before the economic crisis hit the region. The banking sectors of these countries were affected by the level of interest rates the most and its soundness turned out to be a very important risk factor during the financial and economic crisis. If investors had been pricing in the slowly deteriorating situation in the banking sectors of these countries, that would have made their sovereign yields higher. So the results of the regression analysis should not be interpreted as compensation for inflation risk but might be interpreted as a compensation for the risks implied by being a part of the monetary union and its consequences for cyclical development of the economy.

It could also be argued that the higher yields before the financial crisis were sort of a “continuation” of the higher yields before the currency union (despite the fact that they no longer carried a higher inflation risk than the sovereign bonds of the rest of the member countries). In the case of a break-up of the monetary union or in case one of its members left the monetary union, its central bank would determine the level of interest rates in their economy again, and there is a high probability that its policy would be similar to the one conducted before joining the currency union. That would not only influence the level of interest rates but also nominal exchange rates.

Apart from the reasons mentioned above, higher spreads for high-inflation countries could also be the result of a compensation for inflation risk by local investors, since many investors still did not seek foreign investments at the time. There has been an increase in the holdings of foreign bonds in Eurozone but there is still a certain preference for domestic bonds which, as a result, back then reflected domestic inflation rates and the need for a compensation for inflation risk.

The rest of the regression analysis includes other variables related to cost of borrowing and loss of purchasing power. We did not repeat this analysis with the 2008-2013 time periods, since low inflation as a result of low economic growth decreased government

revenues and their ability to meet their debt obligations. Including inflation in this regression analysis may thus lead to the wrong conclusion.

Real interest rates provide a better estimate of the cost of borrowing given the purchasing power. The lower the real interest rates, the higher the incentive to borrow. The results of the regression analysis (3) taking into account real interest rates were not as significant as the results of the regression which took inflation into account. Greece, Spain, France, and Italy were insignificant. The coefficients for Portugal and Ireland, whose economies required slightly higher interest rates than imposed by the European Central Bank, were negative, suggesting that higher real interest rates raised their spreads, as opposed to Belgium, the Netherlands, Austria, and Finland. Higher real interest rates were probably the result of lower inflation during phases of slower economic growth, which might have raised the spreads of Portugal and Ireland, whereas slower economic in the Euro Area might have enticed investors to invest into the “safer” countries, such as Belgium, the Netherlands, Austria, and Finland.

Our last analysis (4) takes into account the loss of purchasing power (Table no. 6). The data is expressed relative to Germany. This is an expression of how much the economy has changed since the nominal interest rates were fixed. This gives us a certain idea about the real exchange rate adjustment since the nominal exchange rates were fixed. This real exchange rate adjustment affected countries’ trade balance which in turn affected the overall level of debt (including private debt).

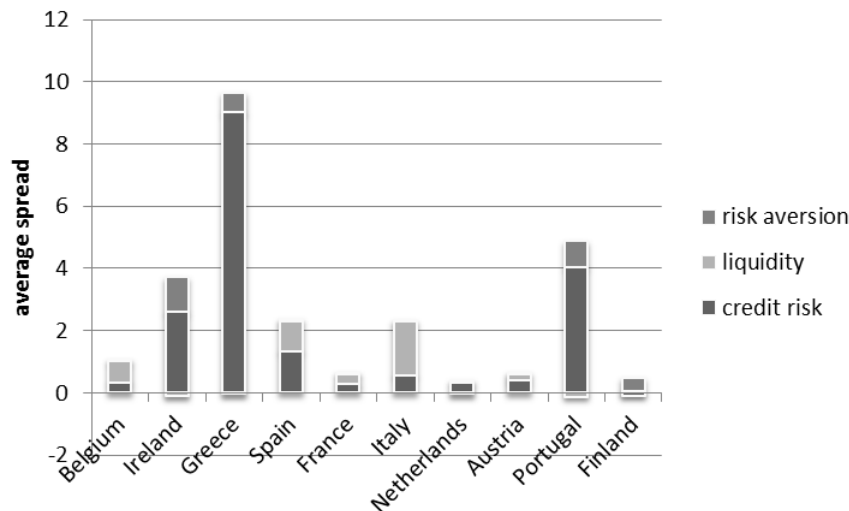
**Table no. 6 – Determinants of Bond Spreads from 2002 until 2008
including overall change in inflation relative to Germany**

Spread 2002-2008	Belgium	Ireland	Greece	Spain	France	Italy	Netherlands	Austria	Portugal	Finland
multiple R	0.60	0.89	0.77	0.68	0.65	0.59	0.61	0.63	0.70	0.71
constant	1.51	-2.14	1.23	-4.42	-0.58	0.74	0.37	1.83	1.63	0.39
<i>p value</i>	0.04	0.00	0.02	0.00	0.20	0.37	0.36	0.00	0.00	0.08
t-stat	2.08	-8.96	2.33	-3.06	-1.28	0.90	0.92	3.54	3.40	1.78
lower interval (95%)	0.06	-2.62	0.18	-7.29	-1.48	-0.91	-0.43	0.80	0.68	-0.05
upper interval (95%)	2.97	-1.67	2.28	-1.54	0.32	2.39	1.16	2.87	2.59	0.83
credit risk	-1.01	3.36	0.54	5.19	2.84	-0.29	-0.15	-1.51	-0.76	-1.66
<i>p value</i>	0.01	0.00	0.13	0.00	0.00	0.60	0.78	0.00	0.17	0.00
t-stat	-2.51	10.63	1.52	3.20	5.86	-0.53	-0.28	-4.86	-1.40	-4.14
lower interval (95%)	-1.81	2.73	-0.17	1.96	1.87	-1.38	-1.20	-2.13	-1.84	-2.46
upper interval (95%)	-0.21	3.99	1.24	8.41	3.80	0.80	0.90	-0.89	0.32	-0.86
liquidity	-0.27	0.02	-0.22	0.41	-0.31	-1.56	0.01	-0.14	-0.08	0.00
<i>p value</i>	0.00	0.00	0.00	0.03	0.21	0.06	0.69	0.00	0.00	0.72
t-stat	-3.15	4.16	-4.26	2.21	-1.25	-1.91	0.40	-3.21	-4.62	0.35
lower interval (95%)	-0.45	0.01	-0.33	0.04	-0.80	-3.18	-0.05	-0.22	-0.12	-0.01
upper interval (95%)	-0.10	0.03	-0.12	0.77	0.18	0.06	0.08	-0.05	-0.05	0.01
risk aversion	1.32	2.54	2.12	1.69	0.64	2.27	0.05	0.63	0.83	1.16
<i>p value</i>	0.00	0.00	0.00	0.00	0.01	0.00	0.81	0.10	0.12	0.00
t-stat	4.12	7.27	6.56	6.69	2.59	4.81	0.24	1.65	1.59	4.25
lower interval (95%)	0.68	1.84	1.48	1.19	0.15	1.33	-0.39	-0.13	-0.21	0.62
upper interval (95%)	1.96	3.23	2.76	2.20	1.13	3.21	0.50	1.38	1.87	1.71
overall inflation	0.48	0.10	-0.05	0.21	-0.64	0.60	-0.11	0.31	0.06	0.22
<i>p value</i>	0.03	0.00	0.06	0.00	0.00	0.00	0.00	0.38	0.13	0.01
t-stat	2.25	11.17	-1.93	3.78	-5.34	3.63	-3.56	0.89	1.52	2.81
lower interval (95%)	0.05	0.08	-0.10	0.10	-0.88	0.27	-0.18	-0.39	-0.02	0.06
upper interval (95%)	0.90	0.12	0.00	0.32	-0.40	0.92	-0.05	1.02	0.14	0.37

Note: Coefficients are significantly different from zero at 95% level if their *p*-values are equal to 0.05 or lower (Wonnacot and Wonnacot, 1990, p. 125)

Source: ECB Statistical Data Warehouse (2014a, 2014b, 2014c, 2014d), Stoxx (2014), own calculations

According to the regression results, there does not seem to be a strong dependency of this variable on bond yields. Inflation data for the respective time period gave us better results. Portugal, Greece, and Austria were insignificant. The rest of the countries were significant but France and the Netherlands showed negative coefficients. Coefficients were significant and positive for 5 out of 10 countries: Belgium, Ireland, Spain, Italy, and Finland.



Source: ECB Statistical Data Warehouse (2014a, 2014b, 2014c, 2014d), Stoxx (2014), own calculations

Figure no. 3 – Contribution to Spread (2008-2013)

The adjusted model (5) could not prove a clear pattern in risk pricing of sovereign bonds. Very short time periods, especially with less than 100 observations, did not show significant results. The only exception was the liquidity coefficient of the Netherlands. We also did not find any significant coefficients for time periods leading up to the financial crisis of 2008, with the exception of liquidity for certain countries. Most of the coefficients that we found were insignificant with a few exceptions, mostly when using data ending during the financial crisis and during 2011.

Credit risk was significant for shorter time periods before the financial crisis for the Netherlands, Portugal, and France. The significance of the credit risk coefficient of France and Greece fell but remained very high for Portugal and rose substantially for Greek sovereign bonds. Greece and Portugal were among the first ones with major sovereign debt issues in the Euro Area. Their ability to service their public debt started to be questioned along with Ireland and Spain. However, regressions of Spain and Ireland, whose debt issues were of a slightly different character, did not yield any significant results, and our analysis could not conclude what factors were determining to the size of their spread. Liquidity influenced the size of the spread of Italy, the Netherlands and Belgium even before the start of the financial crisis, while risk aversion seemed to have a considerable effect on the yields of France and Greece. Our analysis also proved influence of risk aversion on the yield of Austrian and Spanish sovereign bonds but its coefficients were negative. Since the analysis resulted in negative coefficients for these countries and a positive coefficient for France, we cannot assume that negative risk aversion coefficients were the result of a so-called “flight-

to-safety” by the markets. Using longer time periods proved liquidity to be significant for Belgium and credit risk for France. Liquidity, debt, and risk aversion were all significant for Italian and Portuguese sovereign bonds. Past spread was significant mostly only in those analyses which did not find any other significant variables.

Changes in risk pricing occurred mostly during the second half of 2008 and the first half of 2009 when the volatility in the markets was relatively high. Another time period that stands out in our analysis is year 2011. This might have been the result of higher levels of bond purchases by the European Central Bank which started mainly in 2012 or establishment of the European Stability Mechanism in 2012.

5. CONCLUSIONS

Based on our findings, we can conclude that credit risk and liquidity did not affect Euro Area bond spreads before the financial crisis, although they had a significant impact on them afterwards. It is apparent that risk pricing has changed since the start of the financial crisis. While international risk aversion seems to have played an important role in determining bond spreads before the financial crisis, its influence on bond spreads has been limited since then. The influence of macroeconomic fundamentals has risen since the start of the financial crisis, especially for highly indebted countries and countries with banking sectors affected by the mortgage and debt crisis. Bond spreads of sovereigns with relatively worse macroeconomic position and banking sectors affected by the crisis were influenced by heightened risk aversion more strongly than other sovereigns. Illiquidity of sovereign bonds of certain countries did not seem to be affected by international risk aversion this way. It is interesting to note that liquidity seemed to affect mostly larger economies, especially Italy. This is in line with the findings of [Barrios *et al.* \(2009\)](#) but contradicts the findings of [Barbosa and Costa \(2010\)](#). However, it is important to note that the time period of their analysis and also their approach was slightly different from ours. Differences in real interest rates and purchasing power did show a certain level of significance that should be taken into account but it is questionable what the interpretation of the results should be. Including inflation in the 2002-2008 analysis improved the significance of the analysis, which could be a sign of a compensation for the risks associated with being a member of a common currency block.

Taking into account the results of the adjusted analyses, we can conclude that different sovereign spreads reacted to changes in economic and market environment differently and at different times. Deteriorating situation concerning public finances was mostly perceived in Greece and Portugal around the time when they requested a bailout. Spreads were probably also influenced by the market environment and interventions of the central bank and other institutions. A clear and systematic influence of any of our variables could not be proven but it seems that pricing of risk evolves over time, and markets do take into account all of these factors. Their importance rises especially during times of higher market volatility and higher uncertainty but is probably also influenced by the policies of the central bank. Interventions of the central bank in the bond markets change the price of risk that markets evaluate and finding a relation between spreads and idiosyncratic factors becomes more problematic.

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Notes

- ¹.
$$spread_t = \beta_0 + \beta_c C_t + \beta_l L_t + \beta_r R_t + \varepsilon_t \quad (1)$$
where β_c is a credit risk coefficient, β_l is a liquidity coefficient, β_r is a risk aversion coefficient, C_t is credit risk, L_t is liquidity, R_t is risk aversion, ε_t is an error term.
- ². The regression model (1) was changed to:
- $$spread_t = \beta_0 + \beta_c C_t + \beta_l L_t + \beta_r R_t + \beta_I I_t + \varepsilon_t \quad (2)$$
- where
- β_0
- is constant,
- β_c
- is a credit risk coefficient,
- β_l
- is a liquidity coefficient,
- β_R
- is a risk aversion coefficient,
- C_t
- is credit risk,
- L_t
- is liquidity,
- R_t
- is risk aversion,
- ε_t
- is an error term.
- ³.
$$spread_t = \beta_0 + \beta_C C_t + \beta_l L_t + \beta_R R_t + \beta_r r_t + \varepsilon_t \quad (3)$$
where β_r is real interest rate coefficient and r_t is real interest rate. We assumed that lower real interest rates would imply higher spreads, which is justified in the previous chapter, and we adjusted the formula to take this into account. We wanted to avoid negative values entering our regression model, so we added 3% to all of the values. The data was adjusted the following way:

$$r_t = \frac{1}{\left(1 + \frac{n_t}{100}\right) \left(1 + \frac{i_t}{100}\right) + 0.03}$$

where n_t is nominal interest rate (ECB main refinancing rate).

⁴. The last model consists of our usual variables as well as new variables which roughly describes the loss of purchasing power relative to Germany. The regression model (1) was changed to:

$$spread_t = \beta_0 + \beta_C C_t + \beta_L L_t + \beta_R R_t + \beta_P P_t + \varepsilon_t \quad (4)$$

where β_P is a coefficient of the overall change in purchasing power relative to Germany and P_t is an overall change in purchasing power relative to Germany. The overall change in purchasing power relative to Germany P was calculated as the ratio of the respective country value of accumulated loss in purchasing power to the same value calculated for Germany. The first value was calculated first for January 1999, which is the start of the monetary union and equal interest rates:

$$P_1 = \frac{\left(1 + \frac{i_1}{100}\right)}{\left(1 + \frac{i_{DE}}{100}\right)}$$

and the rest of the values were calculated based on the previous month's value:

$$P_t = \frac{P_{t-1} \left(1 + \frac{i_t}{100}\right)}{P_{DE,t-1} \left(1 + \frac{i_{DE,t}}{100}\right)}$$

$$\Delta spread_t = \beta_0 + \beta_1 \Delta spread_{t-1} + \beta_C \ln C_t + \beta_L \ln L_t + \beta_R R_t + \varepsilon_t \quad (5)$$

where β_C is a credit risk coefficient, β_L is a liquidity coefficient, β_R is a risk aversion coefficient, C_t is credit risk, L_t is liquidity, R_t is risk aversion, ε_t is an error term. \ln is the natural logarithm of a variable and Δ denotes difference in comparison to the previous value.

and

$$\Delta spread_t = \beta_0 + \beta_1 \Delta spread_{t-1} + \beta_C \ln C_t + \beta_L \ln L_t + \beta_R R_t + \beta_I I_t + \varepsilon_t \quad (6)$$

where β_I is an inflation rate coefficient, I_t is inflation rate, and ε_t is an error term.

The Durbin-Watson test proved that none of the analyses (5) and (6) had autocorrelated errors.